NOZZLE SELECTION FOR BOOM, BAND AND SHIELDED SPRAYING

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THE BACK POCKET GUIDE

NOZZLE SELECTION FOR BOOM, BAND AND SHIELDED SPRAYING

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Nozzle selection

Nozzle selection should be based on flow rate, spray quality, fan angle and nozzle type

Orifice size: Nozzle size, pressure, spray width per nozzle and speed determine application rate (L/ha). ISO nozzles have the following standard colour codes for orifice size.

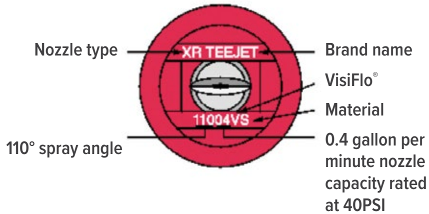
01	015	02	025	03	04
0.39L/min @ 3.0 bar	0.59L/min @ 3.0 bar	0.79L/min @ 3.0 bar	0.99L/min @ 3.0 bar	1.18L/min @ 3.0 bar	1.58L/min @ 3.0 bar
The flow rate of a nozzle size is a multiple of the flow rate of an 01 at the same pressure, e.g. an 03 has three times the flow rate of an 01 at the same pressure.					

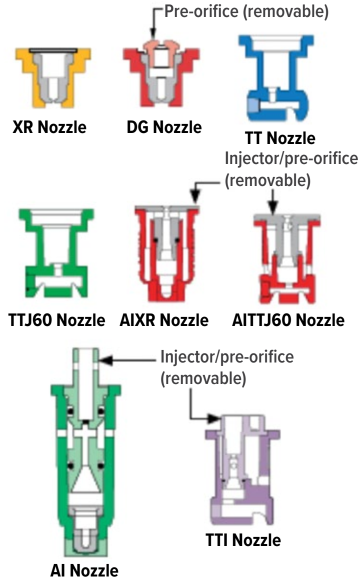
Spray quality: ISO 25358 or ASABE S-572.3 standards describe the range of droplet sizes produced by a nozzle at a particular pressure. (Colours assigned to spray quality are NOT related to colours assigned to nozzle size.)

UC	XC	VC	C	M	F	VF
Ultra Coarse	Extra Coarse	Very Coarse	Coarse	Medium	Fine	Very Fine
Very good drift control ← → Poor drift control						

Fan angle: Determines the width of the spray pattern, which affects the height that the nozzle should be set above the target.

Nozzle type: Nozzles can be identified by the brand name and the type of nozzle. Types include standard, extended range, pre-orifice and air induction nozzles. Many are available as tapered or even patterns. Some are also available as off-set fans or twin fans (diagrams to the right show examples of nozzle labelling and nozzle styles from the manufacturer TeeJet®).





Nozzle types commonly used in grain production

Nozzle types	Images	Main uses	Examples and pressure ranges	Drift control
Pre-orifice		Mostly used for in-crop spraying or for products requiring a medium spray quality. Larger orifices may produce coarse spray qualities at lower pressures	TeeJet® DG, 2 to 4.0 bar, HARDI ISO LD, 1.5 to 5.0 bar TeeJet® TT, 1 to 6.0 bar. **Best operated above 2.0 bar**	Poor to moderate
Low pressure air induction		Mostly used for fallow spraying and some in-crop spraying. Many produce a coarse spray quality, often changing to medium spray quality at higher pressures. Some can produce VC or larger (check individual nozzle charts)	HARDI ISO MINIDRIFT agrotop AirMix® TeeJet® AIXR Lechler IDK 2.0 to 5.0 or 6.0 bar. **Best operated above 3.0 bar**	Moderate to good
High pressure air induction		Good for fallow spraying with fully translocated products and for pre-emergent applications. Good drift control, mostly coarse to very coarse spray qualities. Less suitable for jobs requiring high droplet coverage/leaf retention	TeeJet® AI, HARDI INJET, Lechler ID. 3.0 to 8.0 bar. **Best operated above 5.0 bar, never below 3.0 bar**	Good to very good
Extended range flat fans		Unlikely to be able to be used for applications requiring a coarse or larger spray quality. Larger orifices may be suitable for some foliar applications where a medium spray quality is required at higher volumes.	Hardi F, TeeJet® XR 1.0 to 1.5 bar to 4.0 or 5.0 bar	Very poor

Nozzle types	Images	Main uses	Examples and pressure ranges	Drift control
Twin jets	 	Can provide improved coverage if operated at low travel speeds. Not recommended for speeds above 16-18km/h. Air inducted twins also available	TeeJet® TTJ-60, TeeJet® AITTJ-60 HARDI MINIDRIFT DUO most 2.0 to 6.0 bar	Poor to good
Hybrid	 	Very good for pre-emergent applications and stubble penetration. Suitable for fully translocated herbicide application on moderate to larger-size weeds. Less suitable for jobs requiring high droplet coverage/leaf retention	Turbo TeeJet® Induction (TTI) 1.5 to 7.0 bar. **Best operated above 4.0 bar**	Very good to excellent
Fenceline	 	Used on the ends of boom sections to avoid impacts. Some have a sprayed width of 5m or more and 10x the flow rate of standard nozzle of same colour. (Should be plumbed and operated as a separate section in the controller)	TeeJet® XP BoomJet® (L or R)	Very good to excellent
Streaming		Used for delivery of liquid fertilisers and other products that need to be applied directly to the soil, or to minimise contact with foliage	HARDI QUINTASTREAM TeeJet® StreamJet® SJ-3	Very good to excellent

Spray patterns

Most nozzles are available as tapered-flat fans. Some are also available as even-flat fans.

Tapered-flat fans are most commonly used on booms where double overlap is required to ensure an even distribution across the boom.

Even-flat fans are normally used for banded spraying, under shielded sprayers and on target-selectable sprayers, where overlap from adjacent nozzles is not expected.

Nozzle angle and height above the target

Boom height should be set to achieve a double overlap.

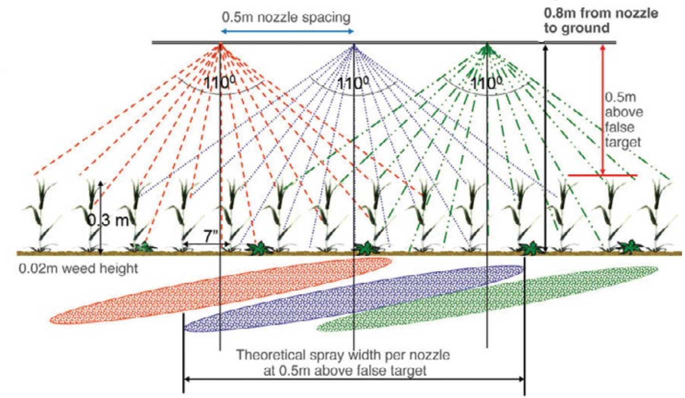
Narrower spray angles require increased boom heights to maintain the double overlap.

Tapered-flat fan nozzle spray pattern

Even-flat fan nozzle spray pattern

SOURCE: PHIL KOSCHITZKE

The weeds to be sprayed in this example are 0.02 metres (2cm) high but the false target, the crop, is 0.3 metres high. If we are using 110° nozzles at 0.5-metre nozzle spacing, the nozzle height should be set to 0.5 metres above the false target (0.8m above ground) to ensure 100 per cent overlap above the obstruction of the crop.



SOURCE: GRAHAM BETTS

Selecting appropriate nozzles using the manufacturer's spray charts

STEP 1: **Determine the application volume (L/ha) and spray quality (check label for required spray quality)**
e.g. 65 to 70L/ha at 16km/h using a coarse spray quality.

STEP 2: **If your nozzle spacing matches the chart (e.g. 50cm) use the nozzle chart to find nozzle sizes and pressures that give the desired L/ha at your average speed (km/h)**
e.g. 65 to 70L/ha at 16km/h with a 50cm nozzle spacing (blue line/circle on chart).

STEP 3: **Identify suitable nozzle types based on their optimum operating pressure at the average speed, and choose an appropriate minimum operating pressure for each nozzle type. For example:**
015 @ 7.0 bar = *High pressure air induction nozzle (minimum operating pressure = 3.0 to 4.0 bar)*
02 @ 4.0 bar = *Low pressure air induction nozzle (minimum operating pressure = 2.0 to 2.5 bar)*
025 @ 2.5 bar = *Pre-orifice nozzle (minimum operating pressure >1.5 bar)*

STEP 4: **Use the recommended minimum operating pressure (red line or circle on chart) for each nozzle type to identify at what speed the desired L/ha can still be achieved when slowing down in the paddock. Dropping below this speed means the nozzles may not work properly if the pressure is too low.**

Choices	Nozzle type	Min. pressure	Min. speed
015 @ 7.0 bar @ 67.5L/ha	High pressure air induction	4.0 bar	= 12km/h
02 @ 4.0 bar @ 68.3L/ha	Low pressure air induction	2.0 bar	= 11 to 12km/h
025 @ 2.5 bar @ 67.5L/ha	Pre-orifice	1.5 bar*	= 11 to 12km/h
		(*not shown on chart)	

Note: Regardless of the nozzle type selected in this example, the speed at which the nozzles no longer perform satisfactorily is approximately the same for all nozzle types (around 11 to 12km/h).

Nozzle flow chart and application rates (L/ha) at various speeds

Nozzle size	Pressure (bar)	Flowrate (L/min/nozzle)	Application rate L/ha @ km/h (at 50cm nozzle spacing, water only)								
			8	10	12	14	16	18	20	22	24
01 (orange)	2	0.32	48	39	32	28	24	21	19	18	16
	3	0.40	59	47	40	34	30	26	24	22	20
	4	0.46	68	55	46	39	34	30	27	25	23
	5	0.50	77	61	51	44	38	34	31	28	26
	6	0.56	84	67	56	48	42	37	33	30	28
	7	0.60	90	72	60	52	45	40	36	33	30
015 (green)	2	0.48	72	58	48	41	36	32	29	26	24
	3	0.59	89	71	58.5	51	44	39	36	32	30
	4	0.68	103	82	68	59	51	46	41	37	34
	5	0.76	115	92	76	65	57	51	46	42	38
	6	0.84	126	100	84	72	63	56	50	46	42
	7	0.96	136	109	91	78	68	60	54	49	45
02 (yellow)	2	0.65	97	77	65	55	48	43	39	35	32
	3	0.79	119	95	79	68	59	53	47	43	40
	4	0.91	137	109	91	78	68	61	55	50	46
	5	1.02	153	122	102	87	76	68	61	56	51
	6	1.12	168	132.0	112	96	84	74	67	61	56
	7	1.21	181	155	121	103	90	80	72	66	60
025 (lilac)	2	0.81	121	97	81	69	60	54	48	44	40
	3	0.99	148	118	99	85	74	66	59	54	49
	4	1.14	171	137	114	98	86	76	68	62	57
	5	1.27	191	153	127	109	96	85	76	69	64
	6	1.40	209	168	140	120	105	93	84	76	70
	7	1.51	226	181	151	129	113	101	90	82	75

L/ha for nozzle size, pressure at the nozzle (bar) and speed (km/h) – based on a 50cm nozzle spacing.

Ask yourself: Are you likely to spend much of your spraying time below the minimum speed?

If you are, there are two possible outcomes:

1. If no minimum hold is set* in the automatic rate controller, the nozzle may not work as effectively when you reduce speed, e.g. fan angles may collapse, spray quality will change.
2. If the minimum hold function is set and you travel at lower speeds, you will be overdosing those areas.
   With some products this may cause crop damage or create plant-back problems (it may be best not to use the minimum hold for in-crop herbicide or pre-emergent applications for this reason).
   To reduce overdosing, a small increase in the application volume will increase the speed range available (this may require a different nozzle choice), or use larger headlands (where practical).

*Minimum hold could refer to speed, litres per minute pressure or litres per minute per nozzle.

STEP 5: Identify the practical volume range that could be obtained for each nozzle, based on the useful pressure range or the limits of pressure for your machine.

STEP 6: Determine which nozzle types provide the greatest flexibility with the pressure range you have available on your machine.

STEP 7: Use manufacturer's spray quality charts to select nozzles that produce the spray qualities required at the application volumes you prefer. You should also consult product labels to determine if there are any restrictions on the types of nozzles that may be used for particular jobs.

Nozzle type	Useful pressure range	Volume range @ 16km/h*
015 high pressure air induction	5.0 to 8.0 bar	56.3L/ha to 74L/ha
02 low pressure air induction	3.0 to 6.0 bar	58.5L/ha to 82.5L/ha
025 pre-orifice	2.0 to 5.0 bar	60L/ha to 93.8L/ha

*Volume range if speed is maintained at 16km/h to ensure that pressure remains constant.

Examples of spray quality charts for various nozzle types

PRE-ORIFICE

HARDI ISO LD-110	bar					
	1.5	2.0	3.0	4.0	5.0	6.0
01 orange	M	M	M	M	F	No data available
015 green	M	M	M	M	M	
02 yellow	M	M	M	M	M	
025 lilac	C	C	M	M	M	
03 blue	C	C	C	M	M	
04 red	C	C	C	C	M	

PRE-ORIFICE

Turbo TeeJet® TT110	bar					
	1.5	2.0	3.0	4.0	5.0	6.0
01 orange	No data available	C	M	M	F	F
015 green		C	M	M	M	F
02 yellow		C	M	M	M	F
025 lilac		C	M	M	M	F
03 blue		C	M	M	M	F
04 red		C	M	M	M	F

LOW PRESSURE AIR INDUCTION

HARDI ISO MINIDRIFT	bar					
	1.5	2.0	3.0	4.0	5.0	6.0
015 green	C	C	C	M	M	M
02 yellow	VC	C	C	C	M	M
025 lilac	VC	VC	C	C	M	M
03 blue	VC	VC	C	C	C	M
04 red	VC	VC	VC	C	C	C

LOW PRESSURE AIR INDUCTED TWIN JET

Air Induction Turbo TwinJet® AITTJ60	bar					
	1.5	2.0	3.0	4.0	5.0	6.0
015 green	Not available in this size					
02 yellow	XC	VC	VC	C	C	M
025 lilac	XC	VC	VC	C	C	C
03 blue	XC	XC	VC	C	C	C
04 red	XC	XC	VC	C	C	C

HIGH PRESSURE AIR INDUCTION

HARDI ISO INJET	bar					
	3.0	4.0	5.0	6.0	7.0	8.0
01 orange	VC	VC	VC	C	C	C
015 green	VC	VC	VC	VC	VC	C
02 yellow	VC	VC	VC	VC	VC	VC
025 lilac	VC	VC	VC	VC	VC	VC
03 blue	VC	VC	VC	VC	VC	VC
04 red	VC	VC	VC	VC	VC	VC

HIGH PRESSURE AIR INDUCTION

Turbo TeeJet® Induction TTI110	bar					
	2.0	3.0	4.0	5.0	6.0	7.0
01 orange	UC	XC	VC	VC	VC	C
015 green	UC	XC	XC	VC	VC	VC
02 yellow	UC	XC	XC	VC	VC	VC
025 lilac	UC	XC	XC	VC	VC	VC
03 blue	UC	XC	XC	VC	VC	VC
04 red	UC	XC	XC	VC	VC	VC

UC	XC	VC	C	M	F
Ultra Coarse	Extra Coarse	Very Coarse	Coarse	Medium	Fine

How many sets of nozzles are needed to cover most jobs?

Most grain growers need at least two sets of nozzles, for example a medium/coarse nozzle for jobs requiring good coverage (in-crop and contact herbicides and possibly fungicides and insecticides) and another very coarse (or larger) nozzle, best suited to summer fallow translocated herbicides, pre-emergents and situations requiring low-drift outcomes. Before purchasing a set of nozzles, ask what else you can do with the nozzles. Well-chosen nozzles should do more than one job, but not necessarily all jobs.

Suggested spray quality and application volumes for most broadacre applications

The arrows on the table below indicate some well-chosen nozzles can do more than one job.

Typical application volume	**Medium spray quality** (lower drift risk areas) *only where permitted on label	**Coarse spray quality**	**Very coarse spray quality**	**Extremely coarse spray quality or larger** (higher drift risk area) **Night spraying** (when no hazardous inversion present)
Lower range 60 to 80L/ha	Bare earth insecticides and miticides	Well-translocated herbicides (low stubble load, low crop interception)	Well-translocated herbicides (low stubble load, low crop interception. Large leaf target)	Not recommended (beware of poor leaf deposition)
Mid range 80 to 100L/ha	In-crop insecticides Fungicides Coverage-sensitive herbicides Pre-harvest desiccation (smaller crop canopies)	Well-translocated herbicides (higher stubble load or crop interception) Pre-emergent herbicides (low stubble load) Coverage-sensitive herbicides (low stubble load)	Well-translocated herbicides (high stubble, moderate crop interception. Not very small leaf target) Pre-emergent herbicides (low stubble load)	Well-translocated herbicides (summer fallow – low/moderate stubble. Large leaf target)
Higher range 120 to 150L/ha	In-crop insecticides Fungicides Coverage-sensitive herbicides Pre-harvest desiccation (smaller crop canopies)	In-crop insecticides Fungicides Coverage-sensitive herbicides Pre-harvest desiccation (larger crop canopies)	Pre-emergent herbicides	Pre-emergent herbicides

Coverage-sensitive herbicides (contact herbicides, Group 1, Group 14) • Well-translocated herbicides (glyphosate, Group 2, Group 4). • 2,4-D must be applied with minimum of VC

Nozzle selection – calculations for different set-ups

Nozzle charts are only useful if the nozzle spacing of your sprayer matches the one used on the chart. Often banded set-ups and shielded sprayers do not have sprayed widths that match nozzle charts (e.g. 50cm), so we must make calculations to select appropriate nozzle sizes or to determine the application rate of the machine.

These formulas apply to any type of sprayer and are based on the sprayed width per nozzle.
The only thing that changes is the sprayed width (explained further below).

The most useful formulas are:

- **L/ha = L/min/nozzle x 600 ÷ speed (km/h) ÷ width (m)**
- **L/min/nozzle = L/ha x width (m) x speed (km/h) ÷ 600**
- **Speed (km/h) = L/min/nozzle x 600 ÷ L/ha ÷ width (m)**
  OR (km/h) = distance (m) x 3.6/time (seconds)
- **Width (m) = L/min/nozzle x 600 ÷ L/ha ÷ speed (km/h)**

Terms used in the formulas

L/ha = litres per sprayed hectare (or total application volume)

L/min/nozzle = the flow rate of each nozzle at a given pressure

600 = a constant conversion factor (when using width in metres)

Width = individual treated width per nozzle in metres. Can be any of the following:

- the nozzle spacing on the boom in metres *(e.g. 50cm spacing = a width of 0.5m);*
- the width of a band from a single nozzle at the target in metres (m); or
- the average sprayed width per nozzle (for a band or under a shield) in metres (m).

  (e.g. two nozzles under a 90cm-wide shield = average width of 0.45m)

Selecting nozzles for banded applications and shielded sprayers

The reason for a banded application is to apply the full rate of product to an area smaller than the whole paddock. When we do this the sprayed area will be less that the total paddock area the machine covers.

Use sprayed herbicides to calculate mixing rates, and paddock (crop) hectares to program the rate controller.

Determining the required flow rate (L/min/nozzle) to select nozzle size and pressure for a shield or band

- The first step is to calculate the average sprayed width per nozzle (m). To do this divide the treated width of the band/shield by the number of nozzles treating that band/shield.
- Then calculate the required flow rate per nozzle (L/min/nozzle)

  Example: What nozzle size and pressure are required to deliver approximately 90L/sprayed ha at a speed of 10km/h using two nozzles per 90cm shield (or band)?

  Average width per nozzle (m) = 0.9 m ÷ 2 nozzles = 0.45m

  L/min/nozzle = L/ha x speed (km/h) x width (m) ÷ 600

  = 90L/ha x 10 (km/h) x 0.45m ÷ 600

  = 0.675L/min/nozzle

  (using a nozzle chart, 0.675L/min = approximately an 015 @ 4.0 bar or an 02 @ 2.2 bar)
- If a different pressure or nozzle size is preferred or available, adjust the L/ha and/or speed (km/h) so the chosen nozzle is working at its optimum pressure.

Determining application and mixing rates (L/sprayed ha) for shields and bands

- L/sprayed ha is the rate used to calculate how much chemical to put in the tank.

  L/sprayed ha = L/min/nozzle x 600 ÷ speed (km/h) ÷ average width per nozzle (m) (i.e. width of band/shield divided by the number of nozzles treating the area)

  Sprayed ha per tank = tank size ÷ L/sprayed ha

  Chemical per tank = chemical rate per ha x sprayed ha per tank

What to put in the rate controller (L/paddock or crop ha) for banded or shielded spraying

- L/paddock ha is the rate that should be entered into the automatic rate controller
- L/paddock ha takes into account how much of the paddock is actually sprayed
- When making calculations for banded or shielded applications, the L/paddock ha will always be less than the L/sprayed.

L/paddock ha = L/sprayed ha x (total width of bands or shields ÷ sprayer width per pass)

Example: A 12m-wide shielded sprayer set-up with 11 x 90cm shields (with 2 x 015 nozzles per shield) and 2 x 45cm guess row shields (with 1 x 015 nozzle per shield).
It is operated at 10km/h and a pressure of 4.0 bar
(an 015 @ 4.0 bar has a flow rate = 0.68L/min/nozzle)

L/sprayed ha = 0.68L/min/nozzle x 600 ÷ 10km/h ÷ 0.45m
= 90.7L/sprayed ha (mix to this rate)

L/paddock ha = 90.7L per sprayed ha x (11 x 0.9m + 2 x 0.45m) ÷ 12m
= 90.7L per sprayed ha x 10.8m ÷ 12m
= 81.6L per paddock ha (this rate goes into the controller)

Selecting nozzle types for banded and shielded spraying

Even nozzles are best for spraying bands.
The sprayed width of a band will be a function of the nozzle spacing, fan angle, nozzle orientation and boom height.

If using a single even fan nozzle to deliver the band then a narrow fan angle is likely to be required. The following table can be used to estimate the sprayed width on the ground relative to nozzle fan angle and boom height above the ground.

Where multiple nozzles are used to treat a single band (i.e. multiple angled nozzles under a shield) this may require physically measuring the sprayed width on the ground for the boom height and nozzle configuration that is to be used and then dividing this width by the number of nozzles to calculate an 'average' width per nozzle.

Changing sprayed width on the ground may be able to be achieved by changing either the boom height, the orientation of the nozzle, or selecting a nozzle with a different fan angle.

When band spraying it is essential to have good boom height stability and control.

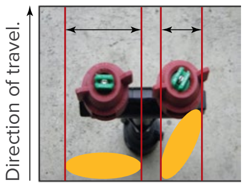
Calculated sprayed width from a single even nozzle at various heights above the target (e.g. the sprayed width of a band on the ground).

Boom height (cm)	Fan angle						
	30°	40°	65°	80°	95°	110°	120°
30cm	16cm	22cm	38cm	50cm	65cm	86cm	104cm
50cm	27cm	36cm	64cm	84cm	109cm	143cm	173cm
70cm	37cm	51cm	89cm	117cm	153cm	200cm	242cm

Approximate band width on ground from a single even nozzle with no overlap.

Adjusting nozzle orientation

Adjusting sprayed width changes the applied rate per ha i.e. the same volume output (nozzle flow rate) is applied to a narrower area.



As can be seen in the picture, adjusting the orientation of the nozzle is a way to adjust the width of the sprayed band. The nozzle on the left will spray a wider band width.

The nozzle on the right will spray a narrower band width due to the angle in its ap. Orienting nozzles as per the configuration on the right may allow a nozzle with a wider fan angle to be used as a banded application.

Sprayer checks and calibration

It is a good idea to ensure that the tank, lines, filters and non-drip check valves are clean before carrying out a calibration.

Set the machine to manual pressure, or use the test speed or auto calibration function to set an application volume (L/ha) and speed (km/h) that will give you a known pressure at the nozzle.

For example, if you are using 02 (yellow) nozzles at 4.0 bar, enter a test speed of 22km/h and an application volume of 50L/ha into the controller. If you have 49 nozzles on the boom the total flow rate should be approximately 45L/min through the boom.

Useful tests:

1. Check the pressure at the nozzle with a pressure gauge screwed into a ¼" female threaded nozzle cap or dropper fitting.
2. Check the pressure at the nozzle across each boom section (every few nozzles) and for each section across the whole boom.
3. If there is a difference in pressure check plumbing for restrictions, non-drip valves and proportional valves (where fitted).
4. When pressure is the same across the whole boom use a tip-tester to compare flow rates. Ensure all nozzles produce the same flow rate per minute (less than 10 per cent variation) by replacing nozzles that are excessively worn. Also replace any nozzle that has a poor spray pattern.
5. If all nozzles are now within 10 per cent variation, use a calibrated jug to measure the flow rate from one of the nozzles to determine the average flow rate for one minute (L/min/nozzle).
6. Compare this flow rate to that of a reference nozzle (ideally one kept aside from original purchase).

CAUTION: RESEARCH ON UNREGISTERED PESTICIDE USE

Any research with unregistered pesticides or of unregistered products reported in this document does not constitute a recommendation for that particular use by the authors or the authors' organisations. All pesticide applications must accord with the currently registered label for that particular pesticide, crop, pest and region.

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